Progress (FY01-FY03)

- Field measurements from the 1998 and 1999 GAME HUBEX were used in studies to intercompare three land surface models (DHSVM, VIC, CLM) and evaluate simulations from the PNNL RCM with and without the use of Four Dimensional Data Assimilation (Leung et al. 2003)
- Historical data were analyzed to study the decreasing trend of sunshine duration and its possible linkage with air pollution (Kaiser and Qian 2002)
- Numerical experiments were performed with a coupled regional climate-chemistry/aerosol model to study the direct and indirect effects of aerosols on the regional climate of China (Qian et al. 2003; Giorgi et al. 2002&2003)

Progress (FY01-FY03)

- A study was initiated with V. Ramanathan of Scripps Institution of Oceanography (SIO) to investigate the effects of aerosols on the regional climate of Southeast Asia based on aerosol forcings estimated from the Indian Ocean Experiment (INDOEX)
- The impacts of precipitation data sources and model resolution on simulations of energy and water budgets and streamflow were examined using a macroscale hydrologic model (VIC), which is being implemented as the new land surface scheme in the PNNL RCM. A new river routing component is also being developed within VIC to enable the PNNL RCM to simulate streamflow (Guo et al. 2003; Liang et al. 2003)

Simulating the Regional Climatic Effects of the Atmospheric Brown Cloud

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Pacific Northwest National Laboratory, Richland, WA

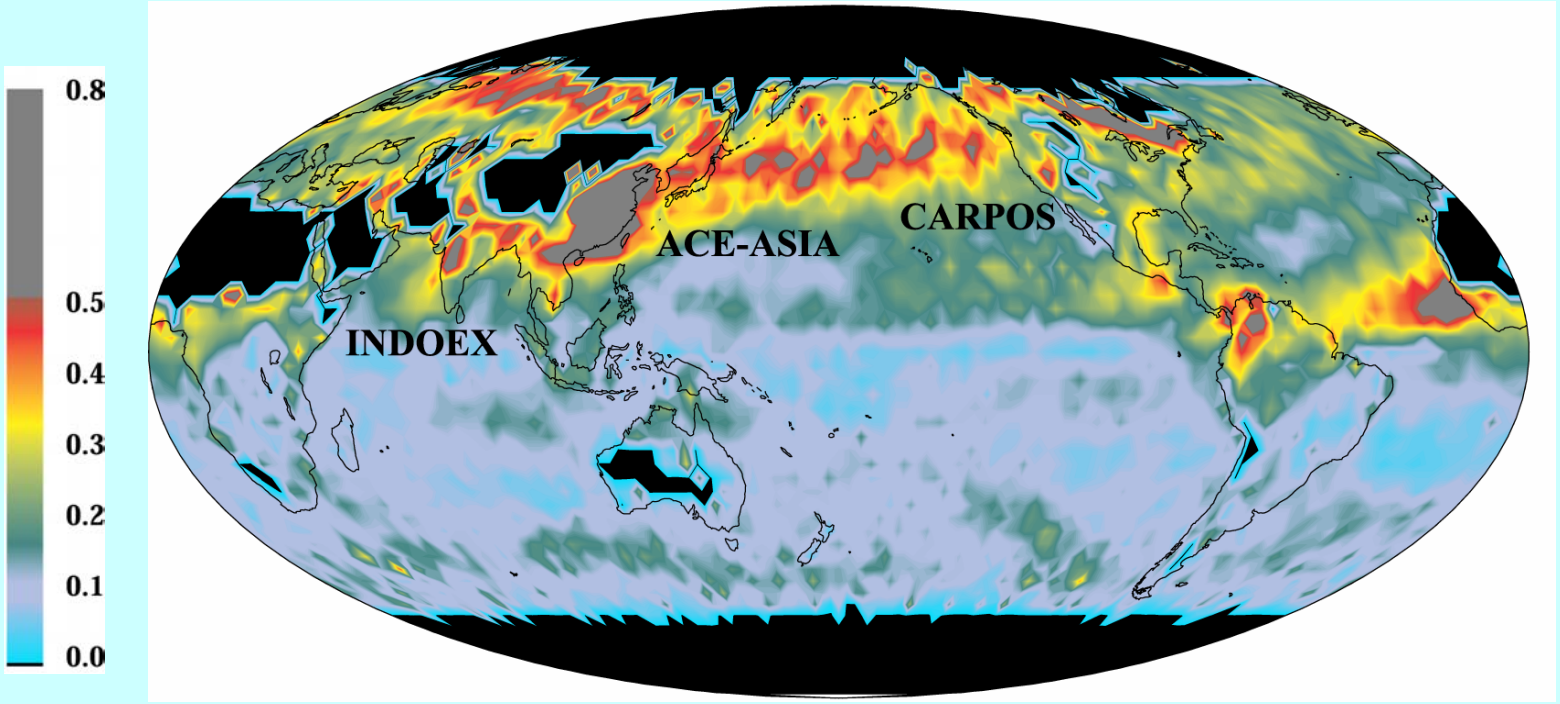
C. Eddy Chung and V. Ramanathan
Scripps Institution of Oceanography, La Jolla, CA

DOE/CMA Science Team Meeting, October 27-28, 2003, Beijing, China

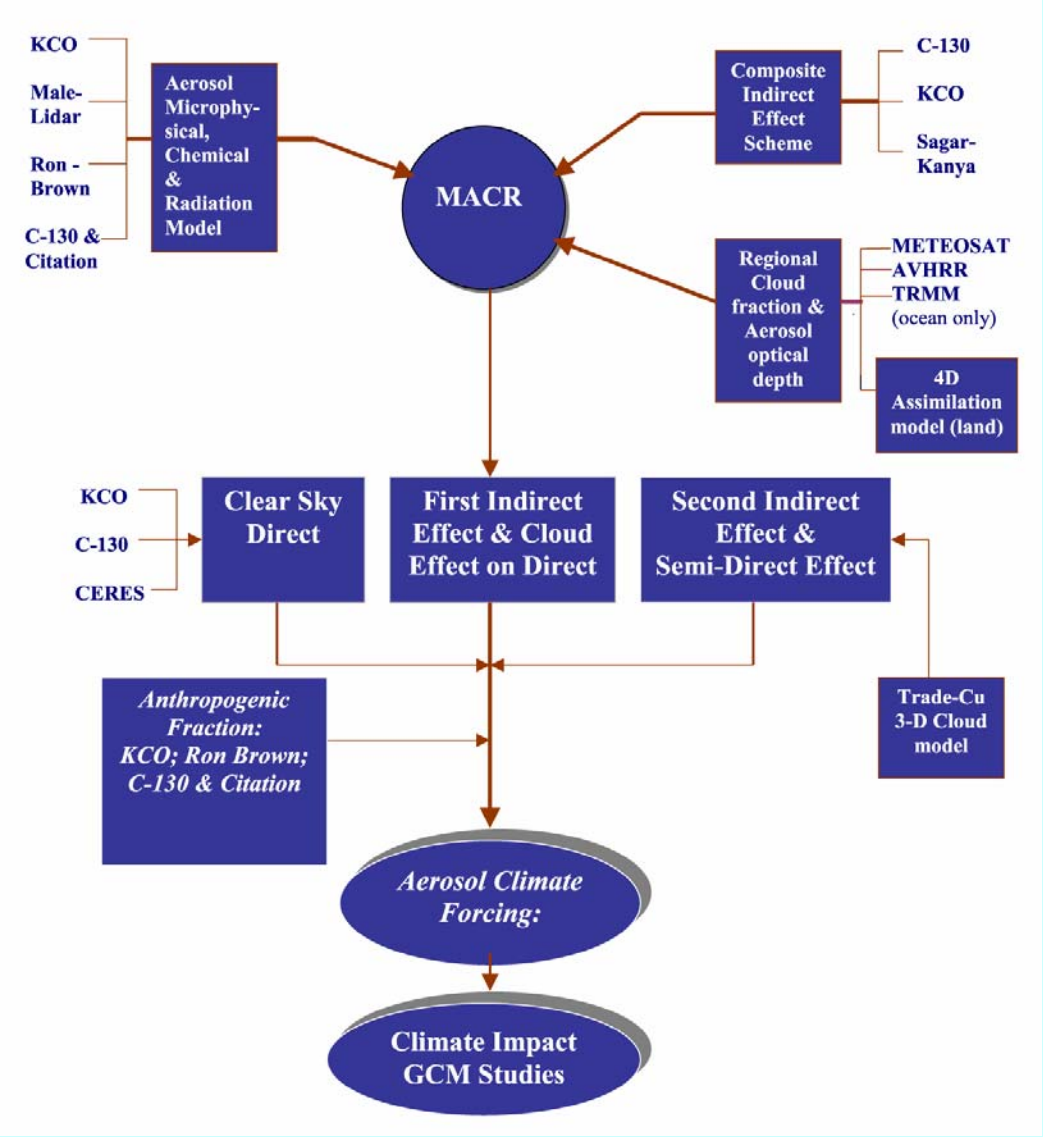
Global Distribution of Natural and Anthropogenic Aerosol Optical Depth at 0.55 μm Derived from MODIS

Atmospheric Brown Cloud (ABC)

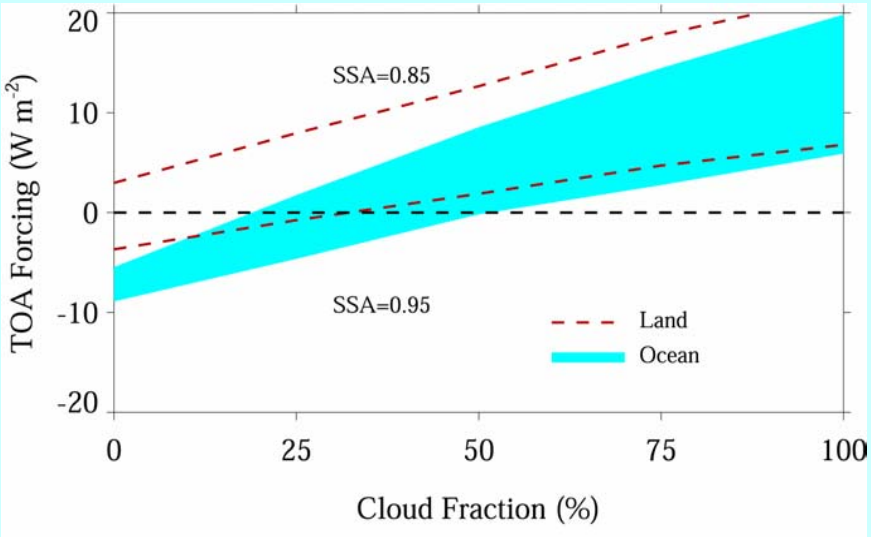
- Industrial aerosols
- Dust particles
- Biomass burning aerosols

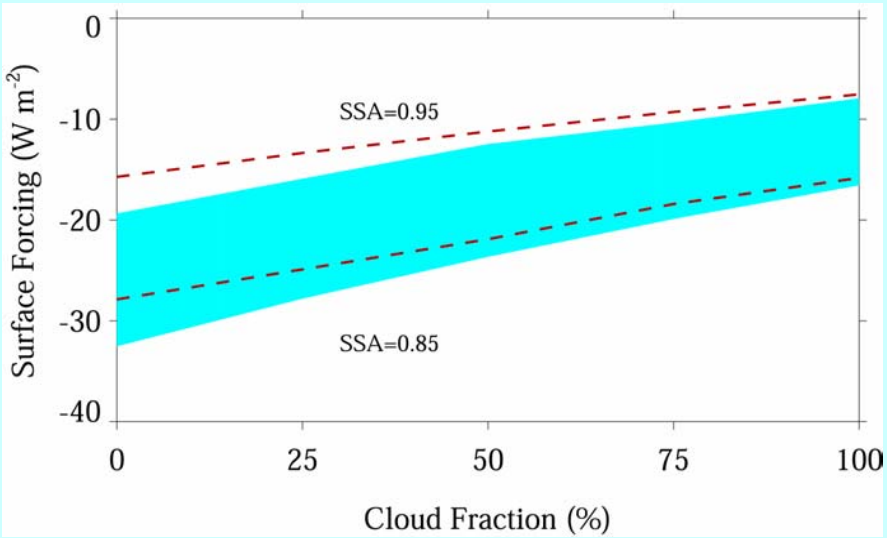


INDOEX Data Integration Scheme (Ramanathan et al 2001a)



Diurnal Average Aerosol Direct Forcing at TOA and Surface vs Low Level Cloud Fraction and SSA (Ramanathan et al. 2001b)



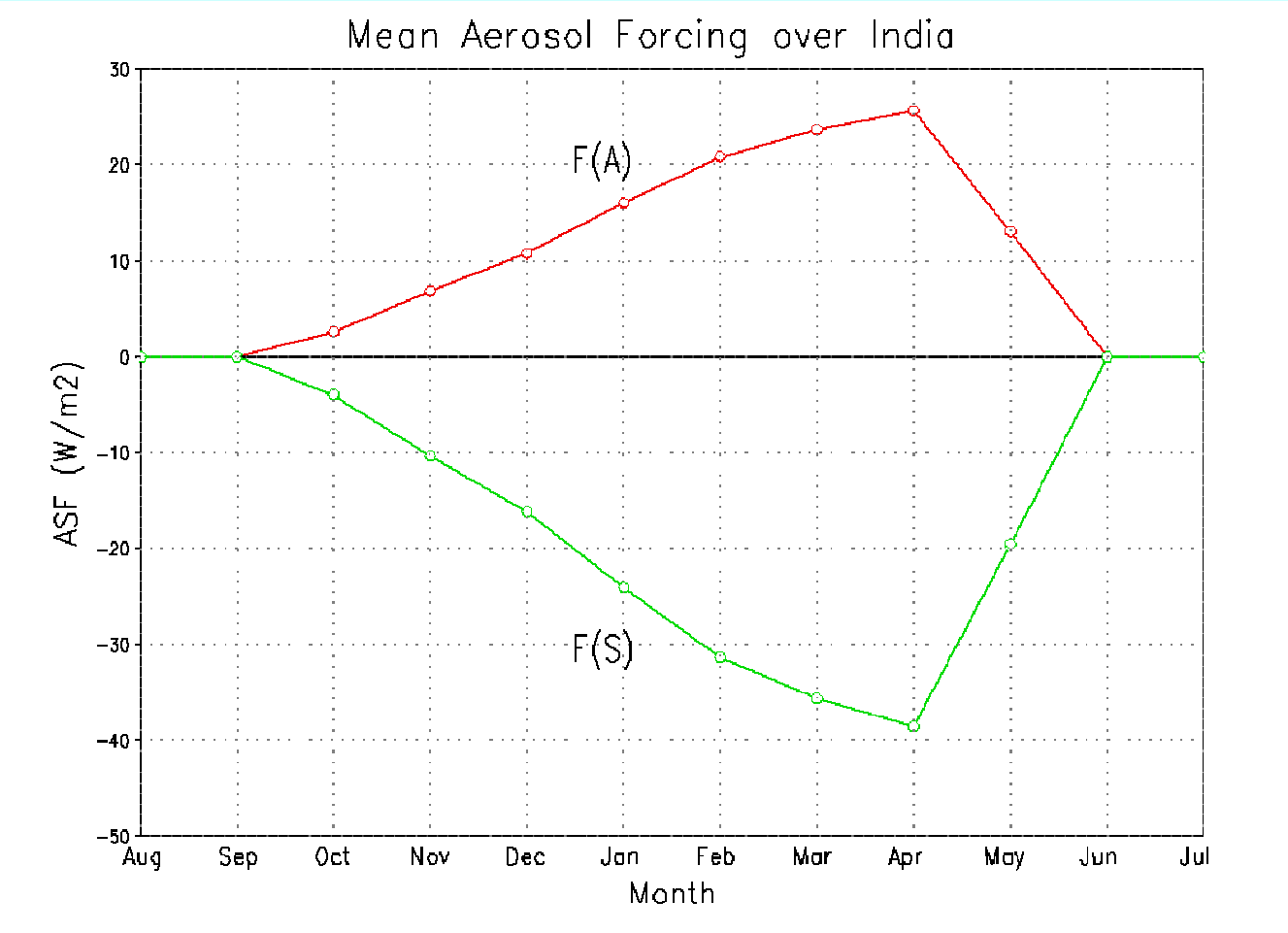


Approach

- Aerosol radiative forcing was estimated based on in-situ and remotely sensed data from the INDOEX and the MACR method
- An MM5-based RCM is applied to the Asian domain at 60 km spatial resolution (150x180 grid cells), with large-scale circulation provided by the ECMWF-TOGA analyses for 1990/10 – 2000/9
- Two 10-years regional climate simulations have been performed with (INDOEX) and without (control) aerosol radiative forcing
- The control simulation is being evaluated with observations, and the impacts of aerosol forcing are investigated by comparing the INDOEX and control simulations

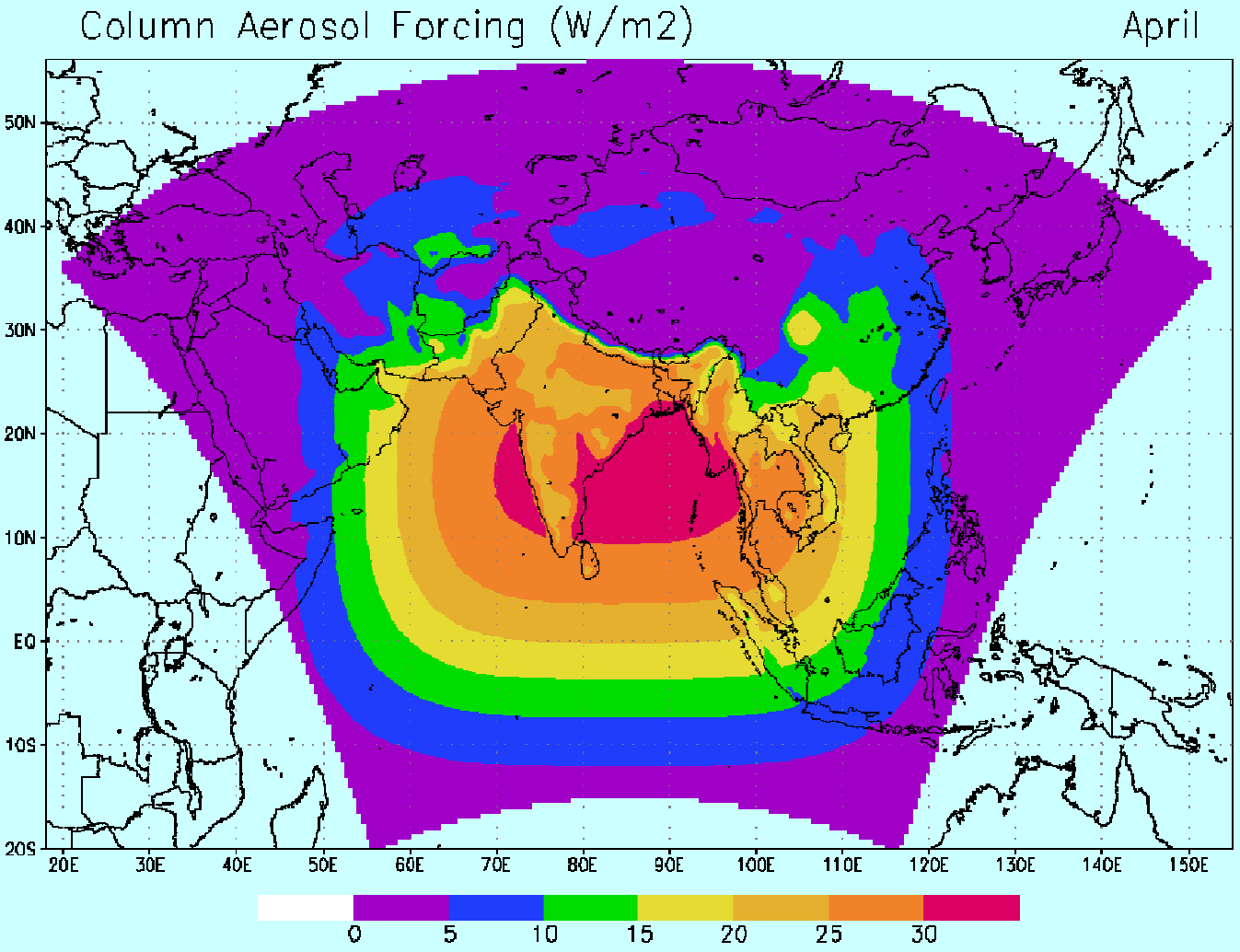
Aerosol Radiative Forcing From INDOEX

F(A) constant from surface to 700 mb

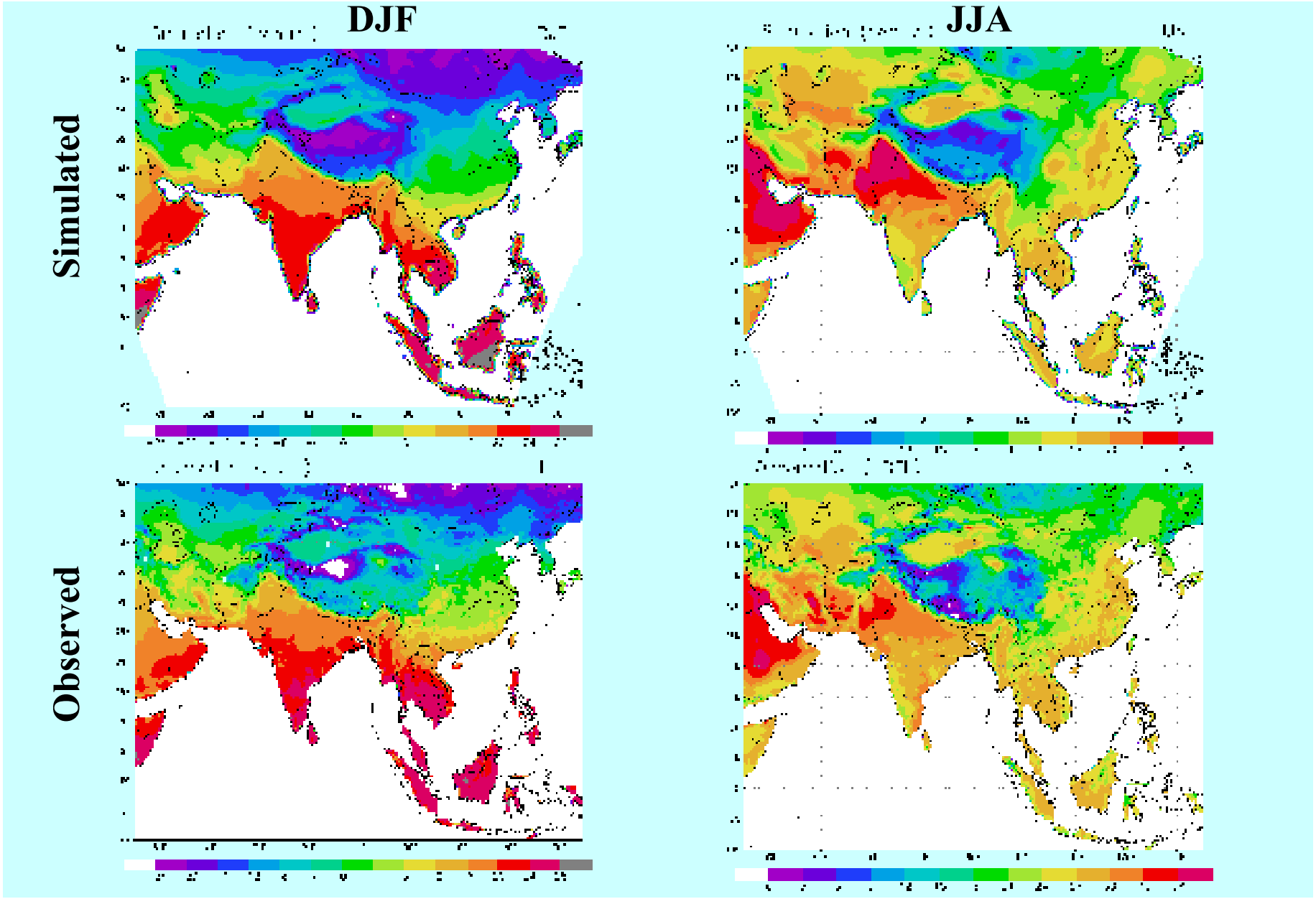


F(S) = -1.5 F(A) for direct radiation; Effective F(S)/F(A) ~ -0.9

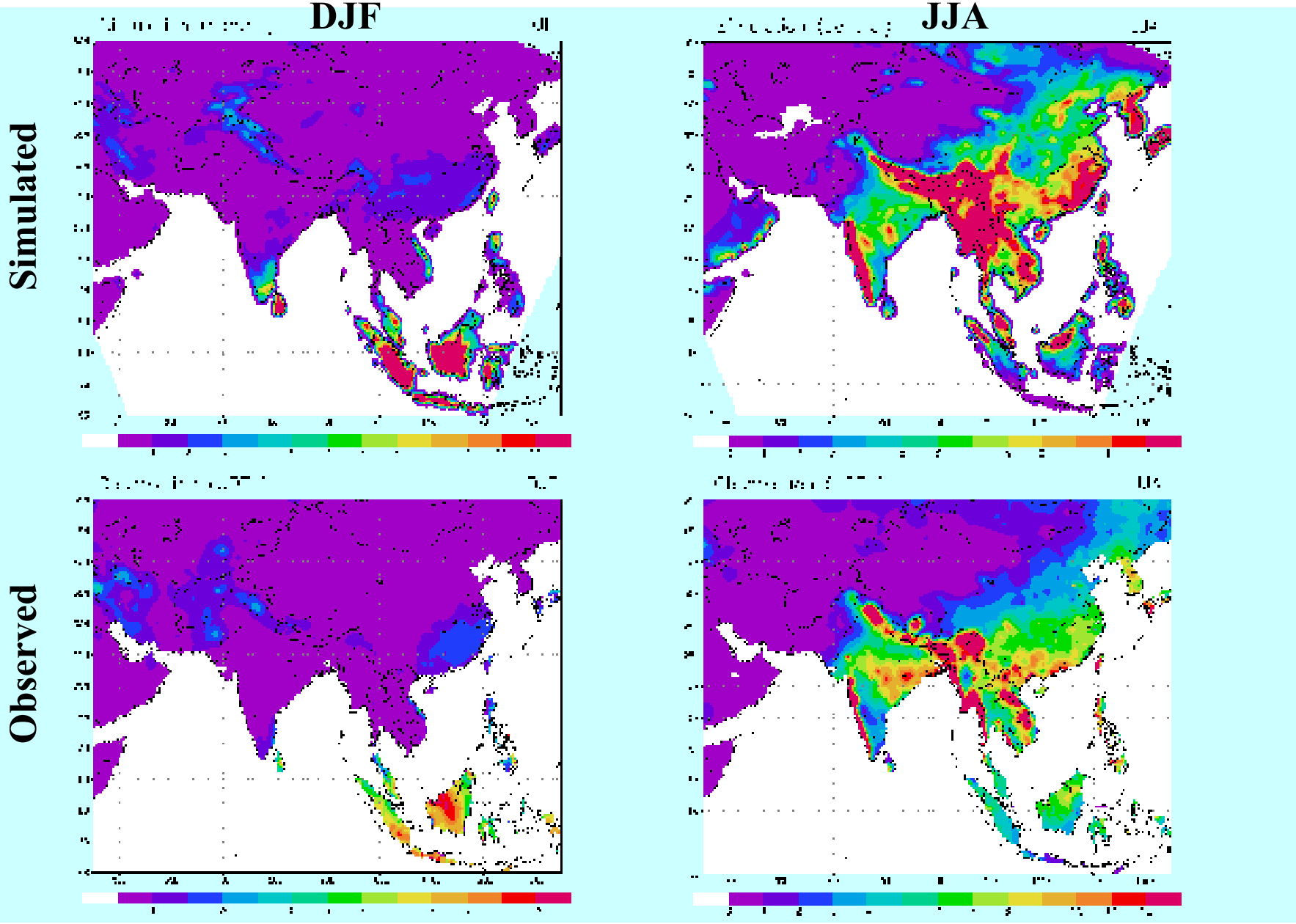
Aerosol Radiative Forcing From INDOEX



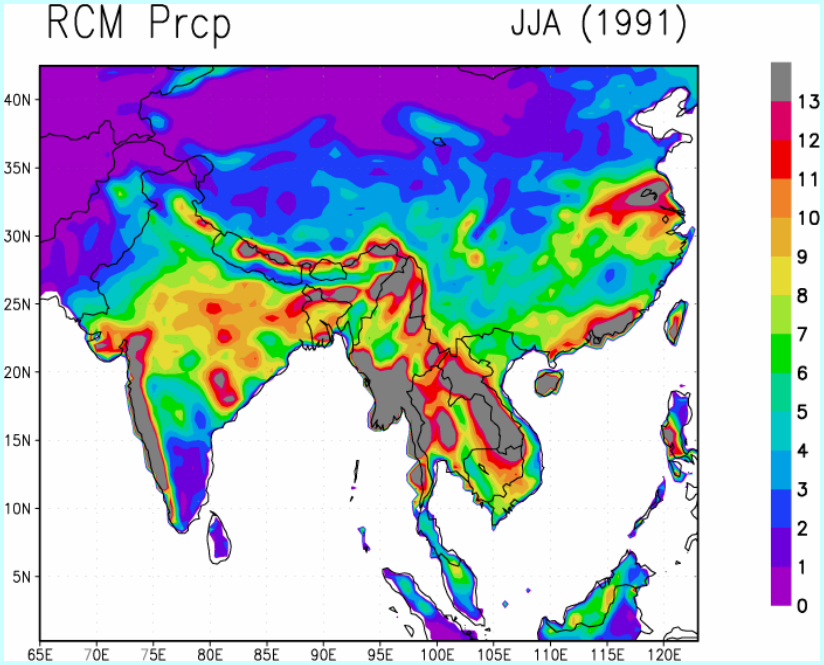
Observed and Simulated Temperature

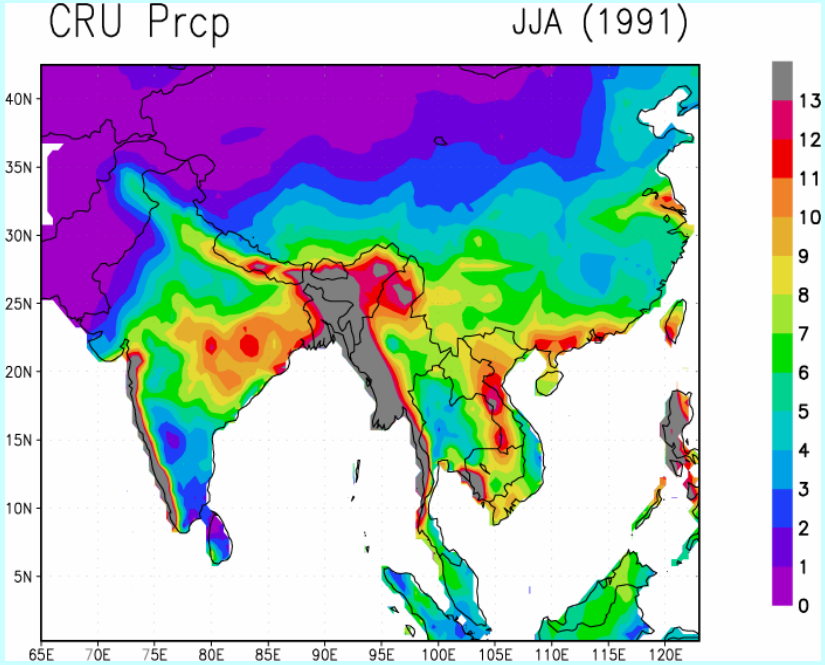


Observed and Simulated Precipitation



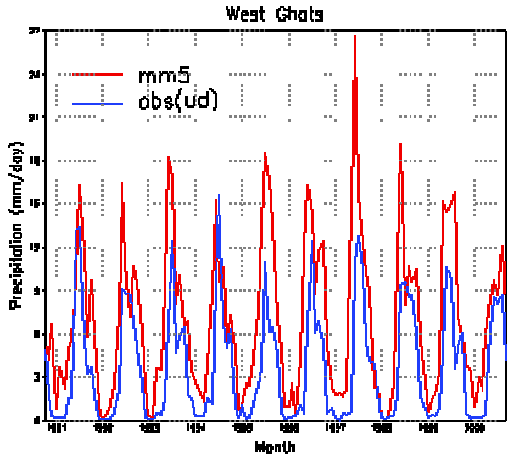
Sensitivity to Domain Size

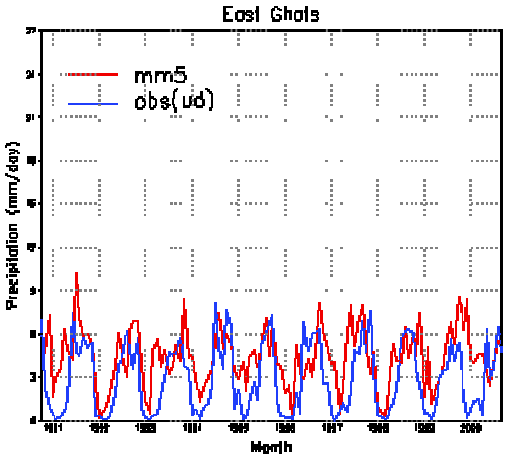


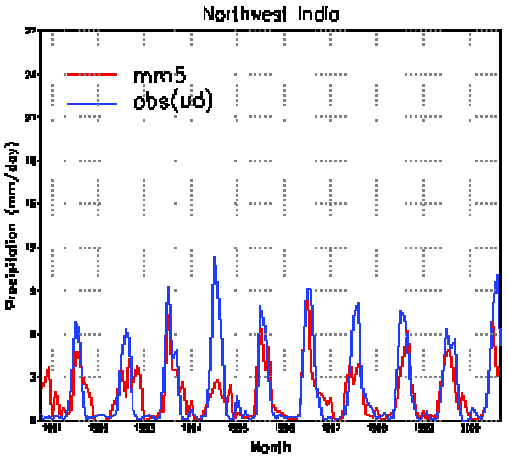


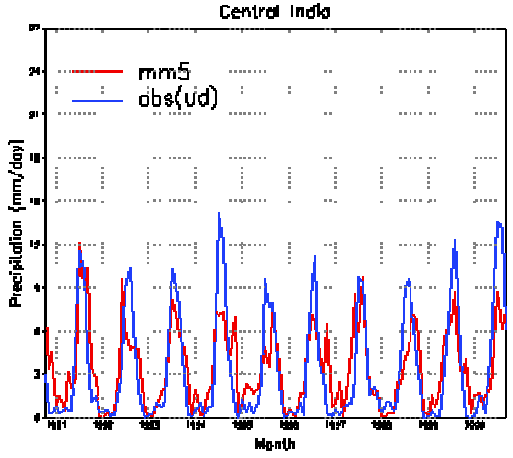
Sub-Regions of India and Tibetan Plateau

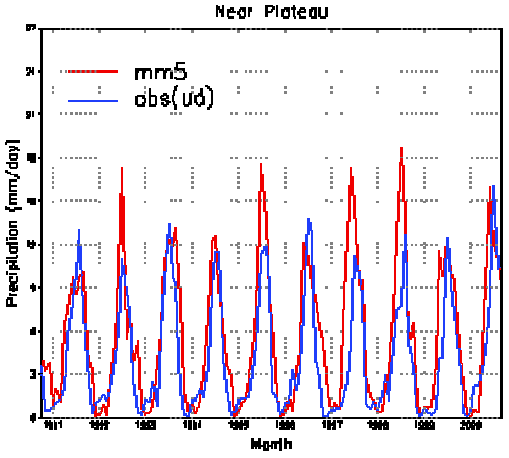
Regional Averaged Monthly Mean P

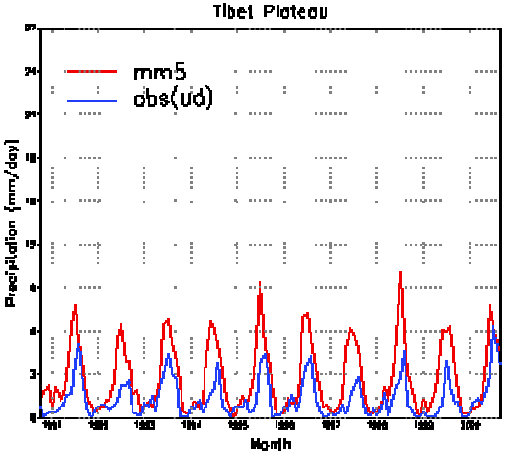




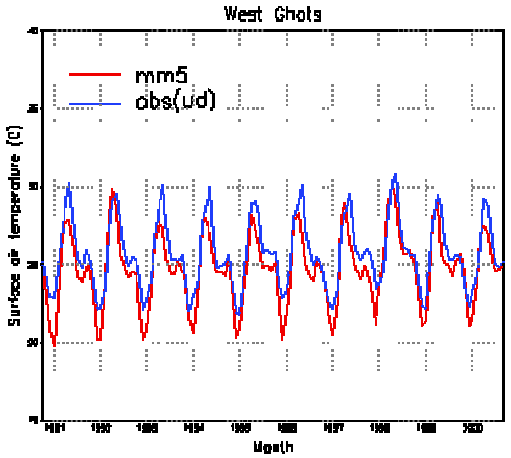


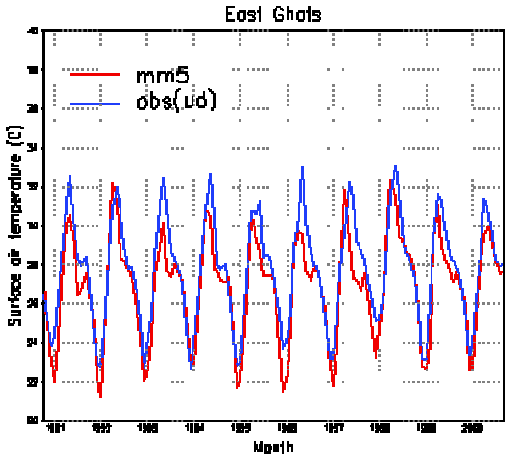


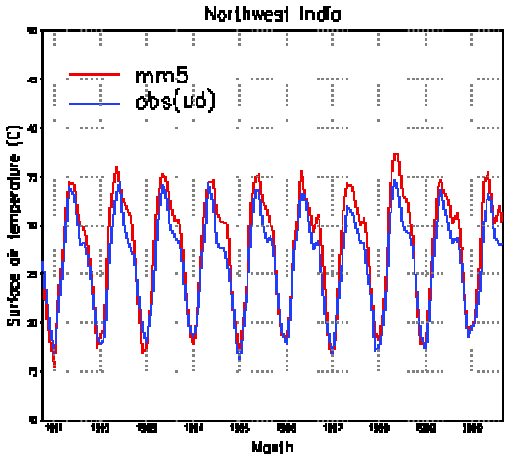


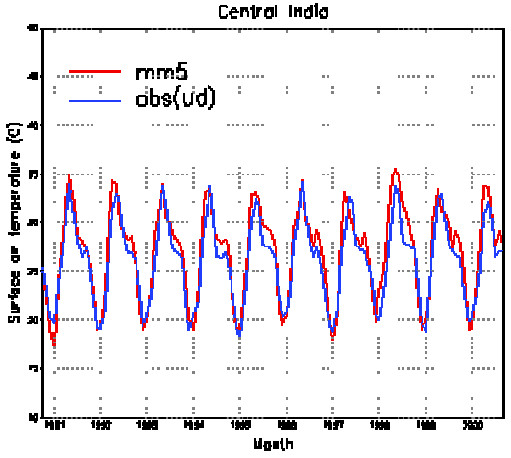


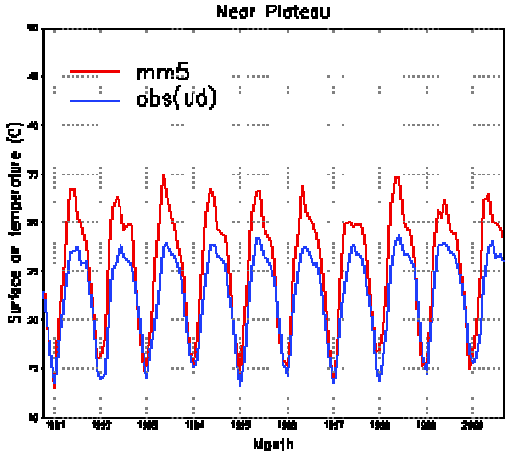
Regional Averaged Monthly Mean T

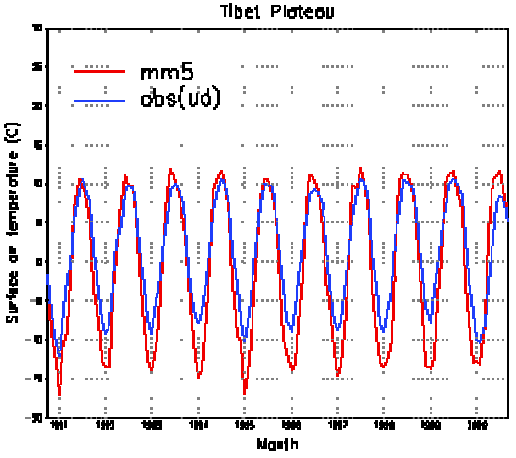




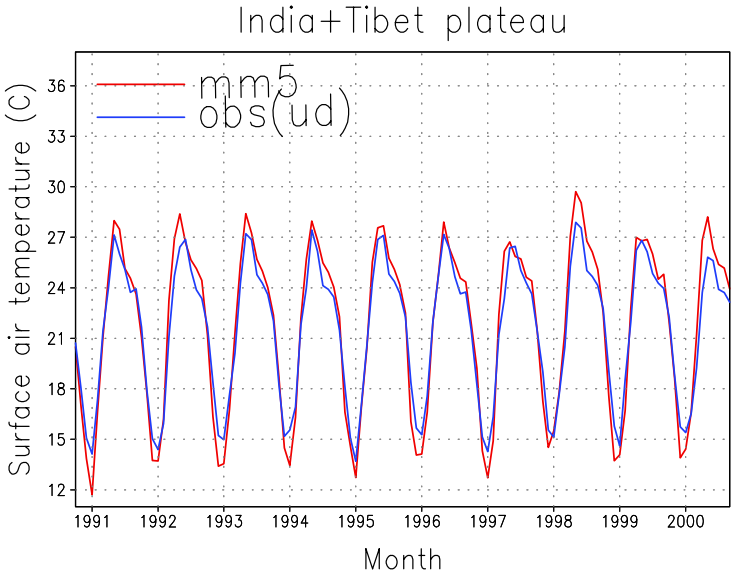


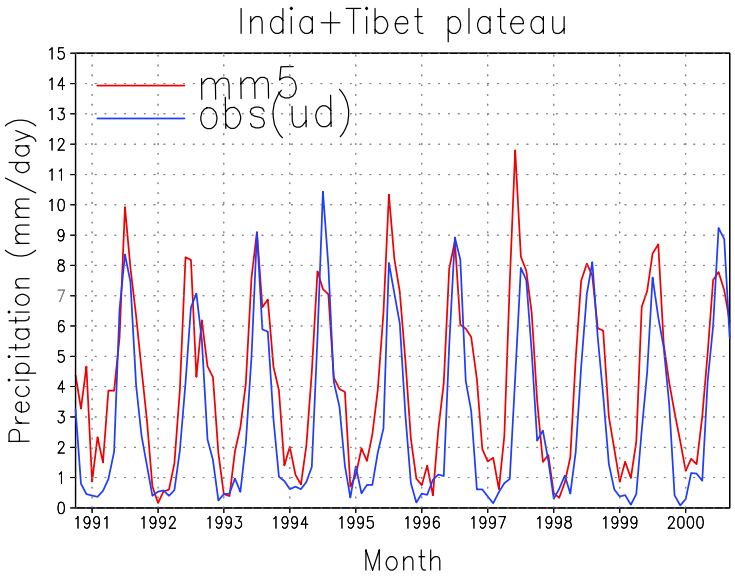




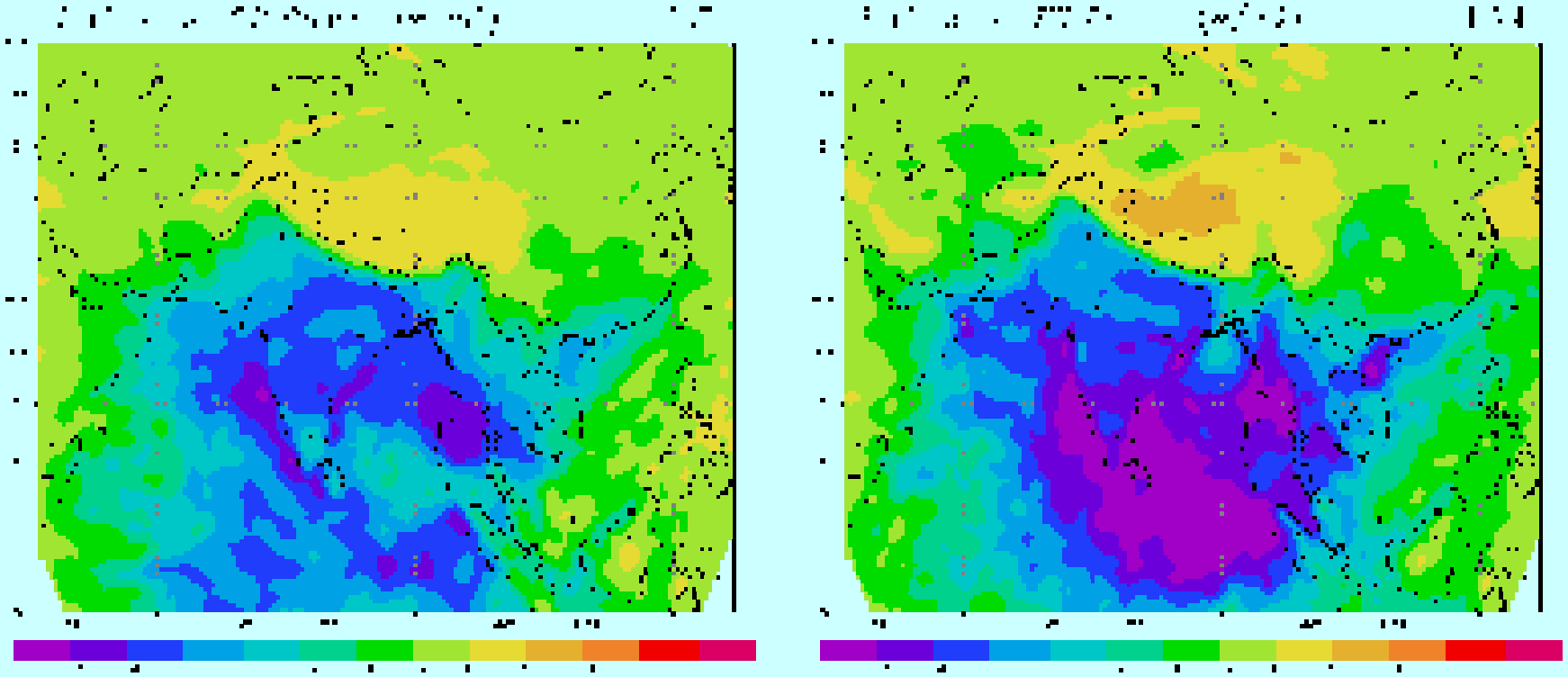


Regional Averaged Monthly Mean T and P

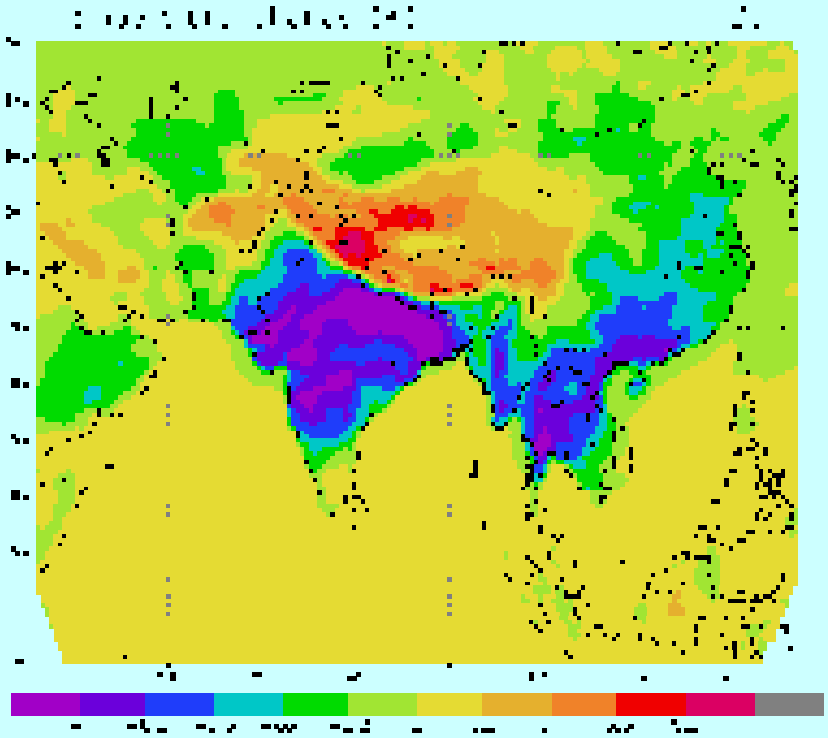


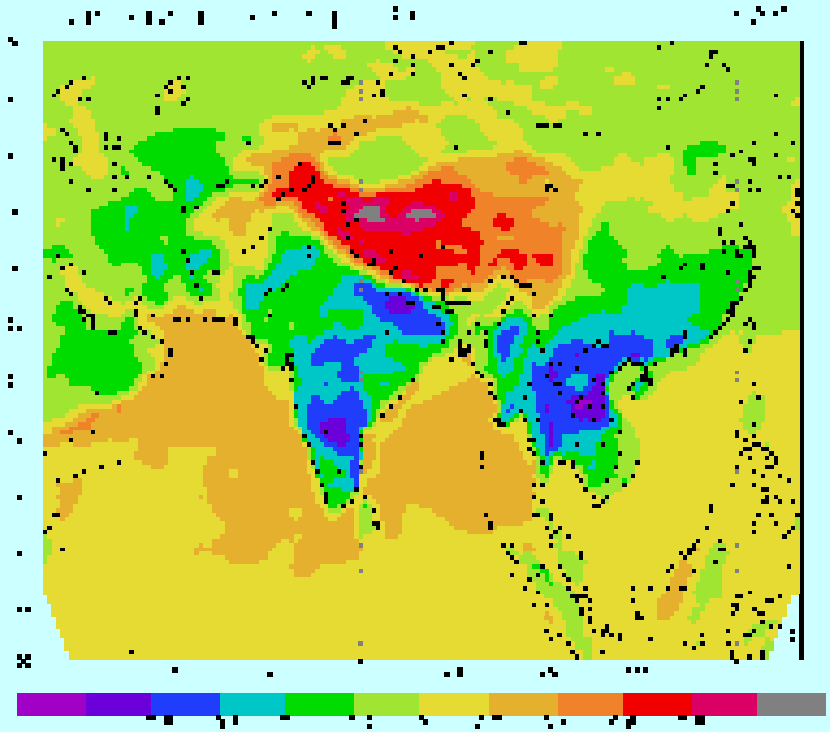


Change in Net Sfc Solar Radiation

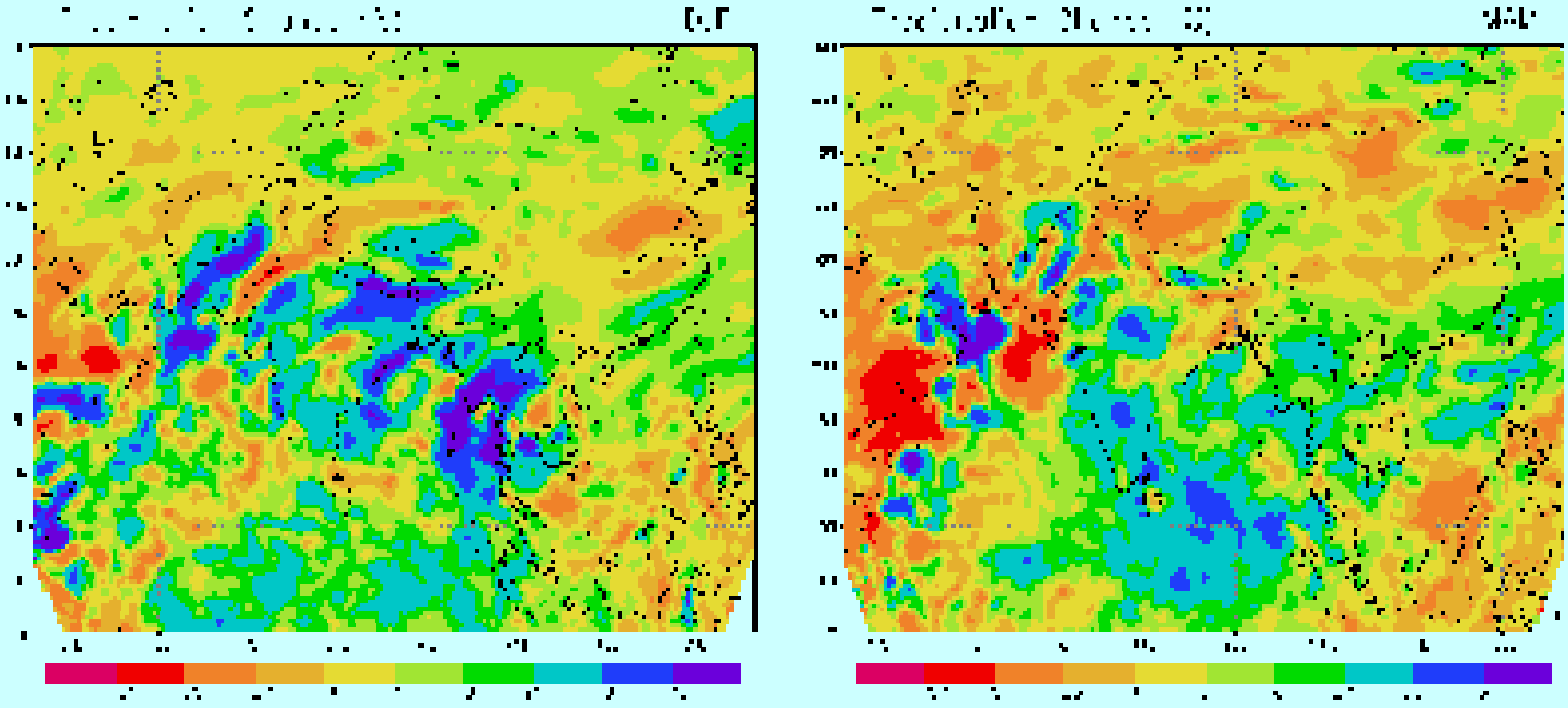


Change in T

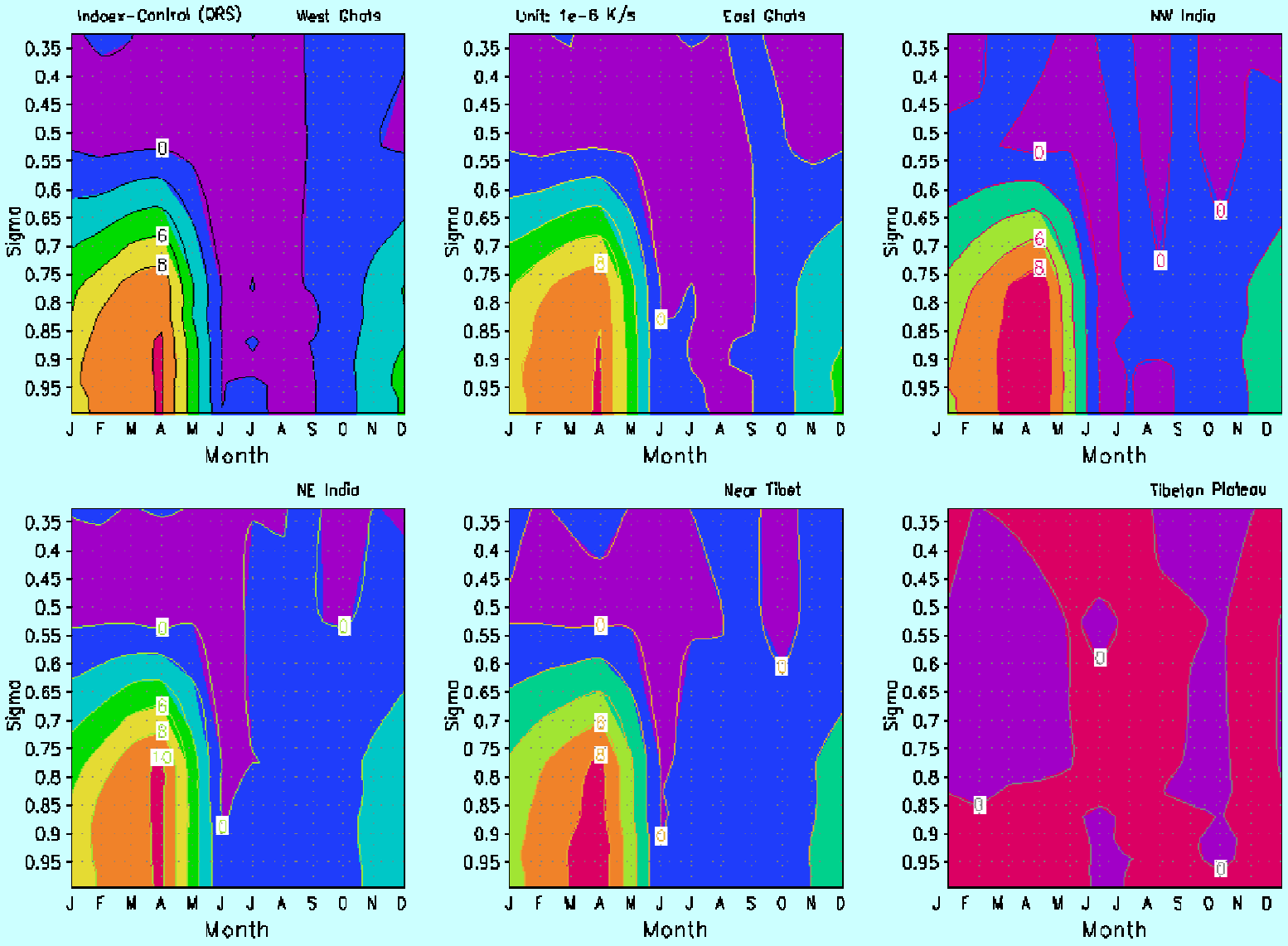




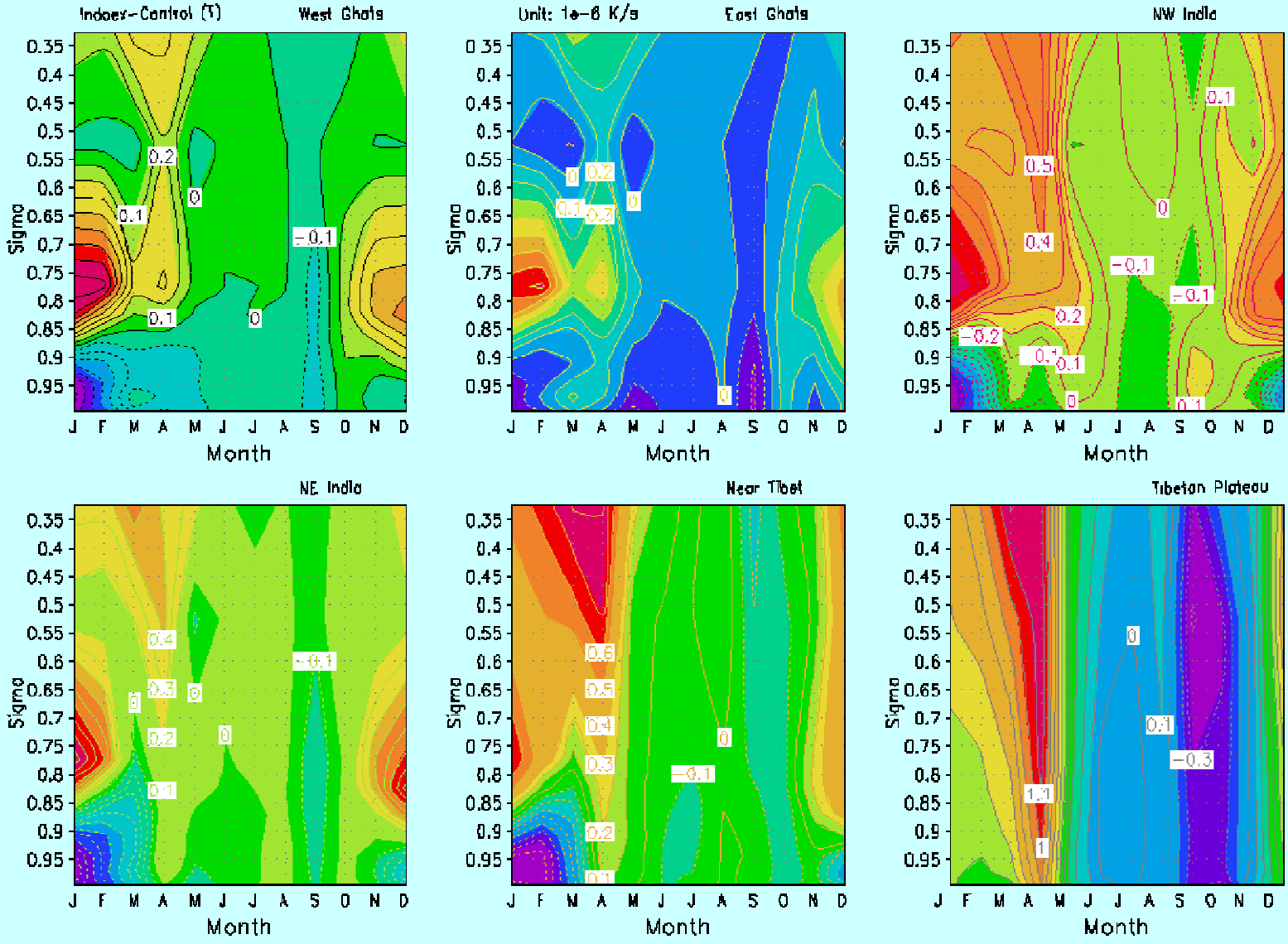
Change in P



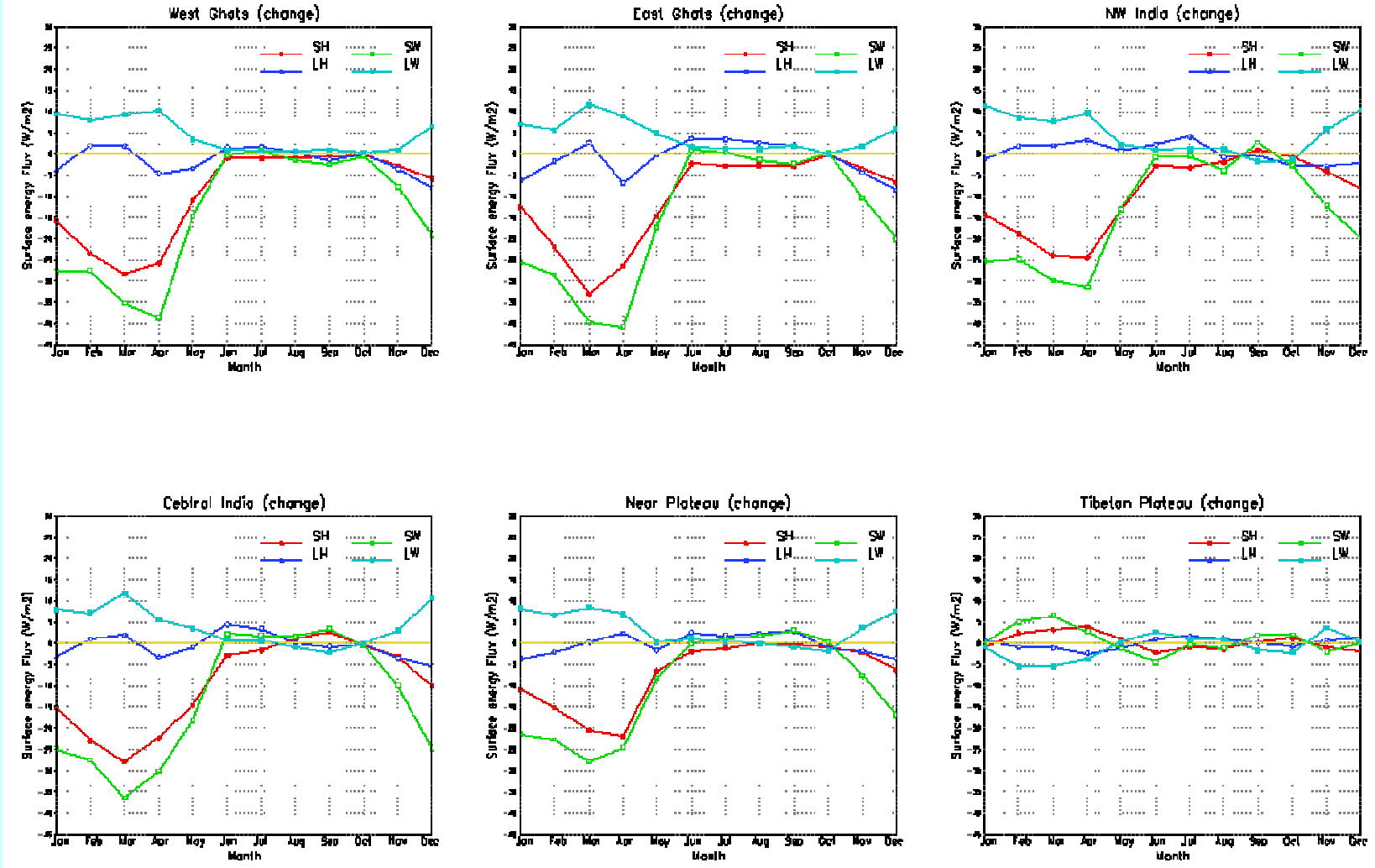
Change in Solar Heating Rate



Change in T

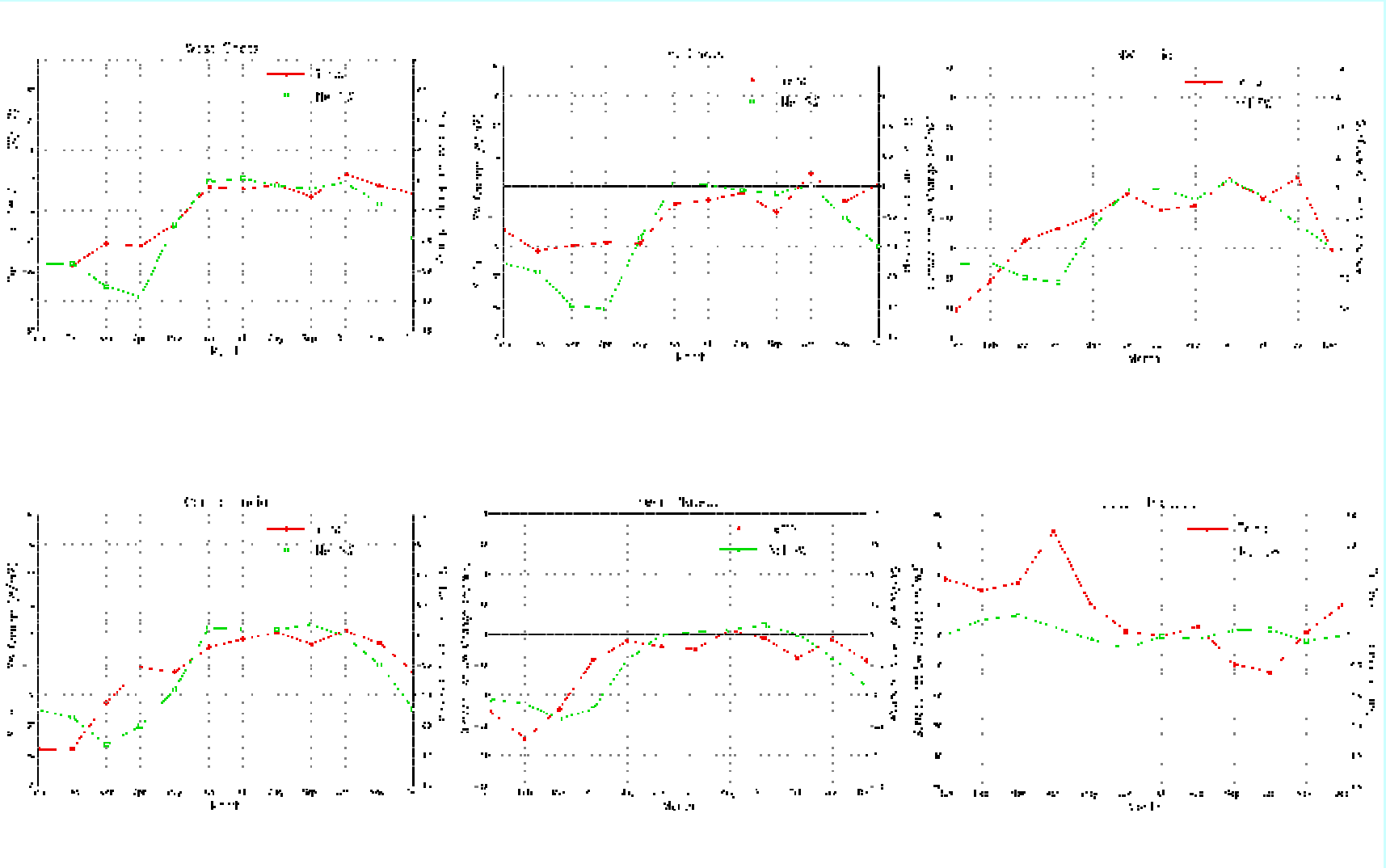

Indoex-Control (T)
West Ghats
Unit: 1e-6 K/s
East Ghats
NW India
NE India
Near Tibet
Tibetan Plateau
Sigma
Month
J F M A M J J A S O N D

Change in Sfc Energy Budgets

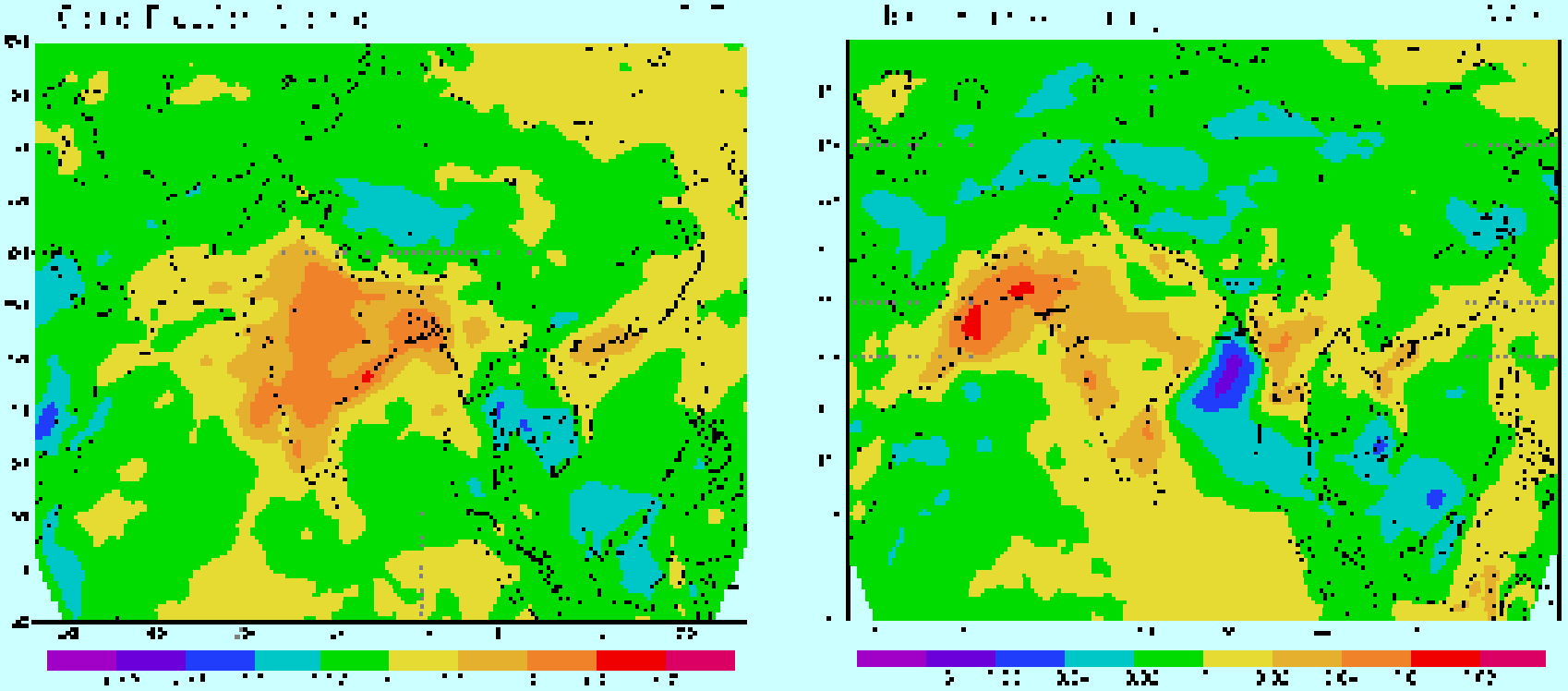


SW/LW – downward (+); SH/LH – upward (+)

Change in SW and T



Change in Cloud Fraction



Summary

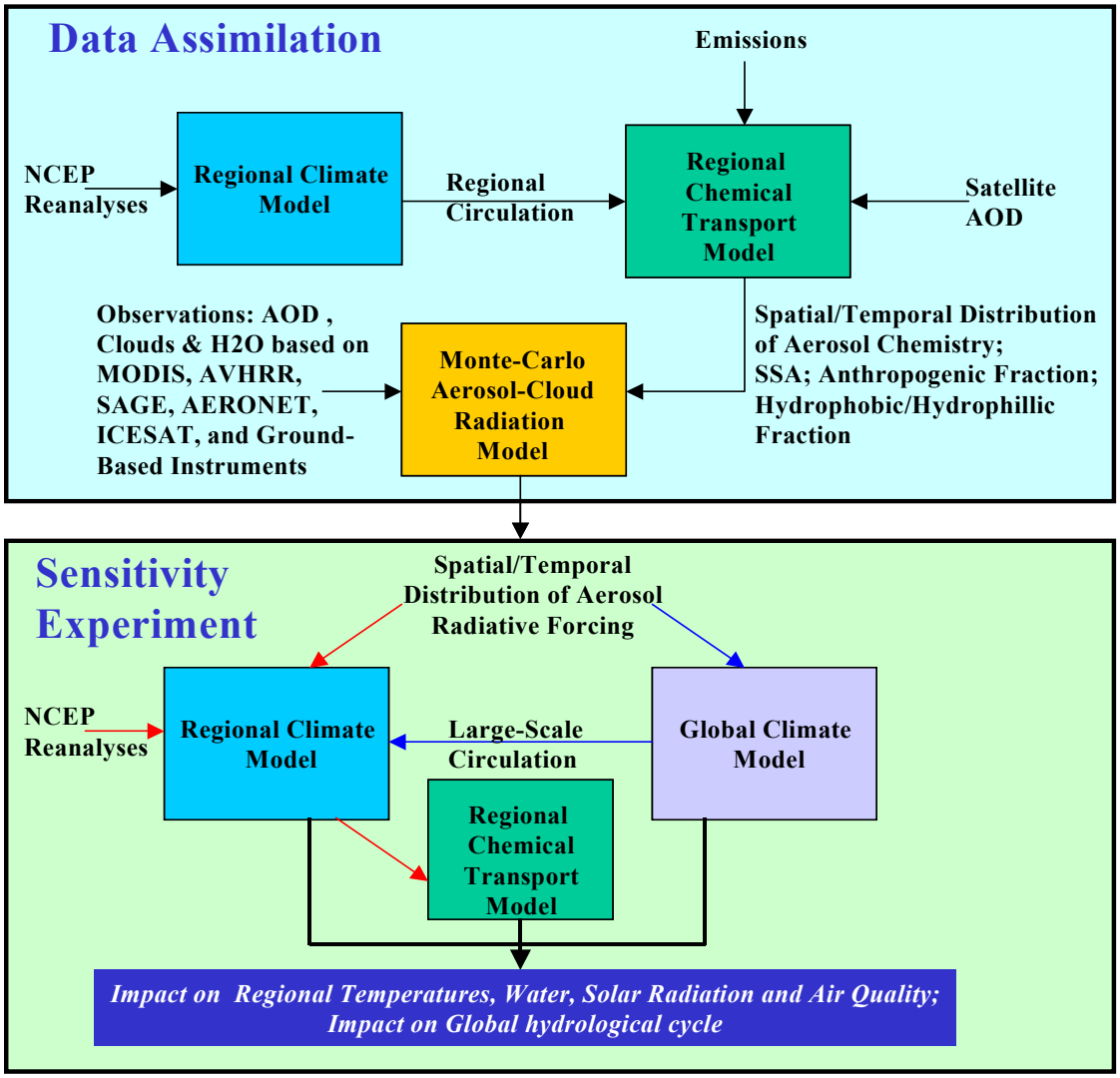
- The contrast between summer and winter monsoon rainfall is well simulated by the RCM over India
- A large wet bias exist over China during summer, which is sensitive to domain size and boundary conditions
- Using prescribed aerosol radiative forcing calculated based on the INDOEX measurements, there is a reduction of net solar radiation at the surface up to 40W/m^2, and a cooling of up to 1^{o}C over India due to the presence of aerosols. In addition, an increase in cloud cover further reduces the solar radiation reaching the surface and cools the surface

Summary

- The largest surface cooling generally precedes the largest reduction in surface solar radiation induced by the aerosols by 1-2 months.
- In the Tibetan Plateau, despite negligible aerosol radiative forcing, there is a reduction in cloud cover, which increases the solar radiation reaching the surface and warms the surface. What causes the change in cloud cover?
- Precipitation generally increases over India during winter and spring, which is accompanied by a large reduction over the Arabian Peninsula

Linking Air Pollution to Regional and Global Climate Change: The Absorbing Atmospheric Brown Cloud (ABC) as a Test Case

V. Ramanathan, L.R. Leung, and G.R. Carmichael



Peer-Reviewed Publications (Since 2002)

- Wang, Y.-Q, **Leung**, L.R., et al. 2003. "Regional Climate Modeling: Progress, Challenges, and Prospects." Japan Meteorological Society Journal, submitted.
- **Leung**, L.R., S. **Zhong**, Y. **Qian**, and Y. Liu. 2003. "Evaluation of Regional Climate Simulations of the 1998 and 1999 East Asian Summer Monsoon Using the GAME/HUBEX Observational Data." Japan Meteorological Society Journal, submitted.
- Guo, J., X. Liang, and L.R. **Leung**. 2003. "Impact of Different Precipitation Data Sources on Water Budget in the VIC-3L Hydrologically-Based Land Surface Model." J. Hydrology, accepted.
- Liang, X., J. Guo, and L.R. **Leung**. 2003. "An Assessment of Spatial Resolution Effects on Simulated Streamflow, Evapotranspiration, and Soil Moisture in a Hydrological Model." J. Hydrology, accepted.
- **Leung**, L.R., Mearns, L.O., F. Giorgi, and R. Wilby. 2003. "Workshop on Regional Climate Research: Needs and Opportunities." Bull. Amer. Meteorol. Soc., 84(1), 89-95.
- **Qian**, Y., L.R. **Leung**, S.J. Ghan, and F. Giorgi. 2003. "Effects of Increasing Aerosol on Regional Climate Change in China: Observation and Modeling. Tellus B, 55(4), 914-934.
- Giorgi, F., X. Bi and Y. **Qian**, 2003, Indirect vs. Direct Climatic Effects of Anthropogenic Sulfate over East Asia as Simulated with a Regional Coupled Climate-Chemistry/Aerosol Model. Climatic Change, 58, 345-376.
- Giorgi, F., X. Bi, and Y. **Qian**, 2002, Direct Radiative Forcing and Regional Climatic Effects of Anthropogenic Aerosols over East Asia: A Regional Coupled Climate-Chemistry/Aerosol Model Study, J. Geophys. Res., 107(D20), 4439, doi: 10.1029/2001/JD001066.
- Kaiser, D. P. and Y. **Qian**, 2002, Decreasing Trends in Sunshine Duration over China for 1954-1998: An Indication of the Increased Haze Pollution? Geophysical Research Letters, 29(21), 2042, doi:10.1029/2002/GL016057.